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Non-Thermal Noise Measurements near Planets

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NOISE MEASUREMENTS
PLANETS (*)

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UMMARY

netary ionization and magnetic fields
urements of non-thermal radio noise
space probe. The noises to be consi-
external to a planet such as cosmic
noise bursts, and (b) noises which
al to a planet such as atmospheric
g with lighting discharges), and VLF
ntly believed to be related to streams
nd such generation mechanisms as
iation and perhaps traveling-wave
med that the measurements could be
ugh to the planet so that the probe
etary magnetosphere. It is expected
cies would be greater than the local
d that the electron density would
from the planet.

d be made by receivers also function-
ments of man-made radio transmis-
ass of experiments adaptable to the
pheres. While noise measurements
great value in determining the noise
and in extending knowledge of the
here is on the information about the
netic fields which may be obtained.

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Magneto-ionic theory suggests that the spectrum of noise which may be observed at the probe will consist of (*a*) an upper frequency range whose lowest frequency will be the plasma frequency local to the probe, and in which range the noise will reach the probe via conventional ionospheric propagation; and (b) a lower frequency range whose highest frequency will be the electron gyro-frequency local to the probe, and in which range the noise can reach the probe by propagating in the whistler-mode, or, for the extremely low frequencies, in various hydromagnetic modes (which will not be considered here).

From the high frequency noise measurements :

(1) The local plasma frequency along the trajectory may be obtained by noting the lower-frequency-cutoff in the cosmic noise (assuming cosmic noise sources are isotropic).

(2) An estimate can be made of the variation of outer ionization density with radial distance by combining the cosmic-noise-cutoff measurement with the somewhat greater lower-cutoff-frequency of the enhanced noise intensity which should be observed from strong discrete sources such as the sun and Jupiter. Ray path considerations show that, for frequencies lower than some critical value, the probe will be within an occulted zone relative to the discrete source. The discrete noise lower cutoff frequency will be a function of probe-planet distance, planet-source angle, and planetary electron density variation. Simple considerations show that the ratio of enhanced discrete noise cutoff to cosmic noise cutoff frequencies is greatest and most sensitive to the variation of planetary electron density for small planet-source angles. A minimum number of discrete events would provide useful information. Should more than one discrete source be present coincidentally, the interpretation is more complicated but still possible.

(3) An estimate of the maximum plasma frequency of the planetary ionosphere may be obtained from noting the cutoff in

c noise (if present) which is able to pene-
phere.

y noise, whistlers and VLF emissions are
ce. If no magnetic field exists, no VLF
fact of importance in itself. If a magnetic
planetary atmospheric lightning, whistlers
the low frequency measurements :

the minimum electron gyro-frequency
ation path (approximately along a magne-
tained from the determination of whistler
the frequency of minimum time delay.

the integrated electron density along the
btained from a measurement of time delay

the electron temperature in the exosphere
ing the upper cutoff frequency of the whist-
rpretation is based on Landau damping.

te height of the lower ionosphere may be
lower cutoff frequency of whistler spectra
ch have propagated between the planet and
distance before penetrating the ionosphere.
nalogous to a waveguide-cutoff effect and is
whistlers.

gnetic field exists, VLF emissions should be
of the many types of VLF emissions is not
mpared to whistler theory, and consequently
can be obtained from their observation is
mission is discrete and periodic, it can be
sion is echoing along a field line in the whist-
, approximate information on the minimum
cy along the path may be obtained from a
upper cutoff frequency of the spectrum, and

information on integrated electron density along the path may be obtained from measurements of the echo period.

The proposed measurements require the determination of cutoff frequencies and time delays or echoing intervals. The accuracy with which the various parameters may be determined, depends upon resolution in time and frequency. In general, for deep space probes, the instrumentation would consist of many fixed-frequency receivers whose outputs would be digitally sampled. The number of receivers and the sampling rate would be limited primarily by the telemetry system data transmission rate. Specific instrumentation could be designed to investigate some of the outstanding questions of particular planets.

The data on ionization and magnetic fields that would be obtained from the interpretation of noise measurements are of an indirect nature, and the noise measurements are here proposed to supplement more direct measurements as might be made by devices such as magnetometers, Langmuir probes, ion traps, etc. Noise measurements would increase the probability of overall success of a planetary probe without resorting to redundant instrumentation. It is therefore felt that non-thermal measurements should be included among the experiments to be performed on the first probes designed to study planetary atmospheres.